WHAT IS CLAIMED IS:

1. A method for evaluating a material specimen, comprising:

mounting a neutron source adjacent the material specimen;

mounting a detector adjacent the material specimen;

bombarding the material specimen with neutrons from the neutron source to create prompt gamma rays within the material specimen, some of the prompt gamma rays being emitted from the material specimen, some of the prompt gamma rays resulting in the formation of positrons within the material specimen by pair production;

collecting positron annihilation data by detecting with the detector at least one emitted annihilation gamma ray resulting from the annihilation of a positron, the detector producing the positron annihilation data;

processing collected positron annihilation data in accordance with a Doppler-broadening algorithm; and

continuing to collect and process positron annihilation data to measure an accumulation of lattice damage over time.

2. The method of claim 1, further comprising:

collecting prompt gamma ray data by detecting with the detector at least one emitted prompt gamma ray, the detector producing the prompt gamma ray data;

calculating positron lifetime data from the positron annihilation data and the prompt gamma ray data; and

continuing to collect positron annihilation data and prompt gamma ray data and

calculate positron lifetime data to measure an accumulation of lattice damage over time.

3. The method of claim 1, wherein said mounting a neutron source adjacent the material specimen comprises mounting the neutron source to the material specimen.

4. The method of claim 3, wherein said mounting a detector adjacent the material specimen comprises mounting the detector to the material specimen.

5. The method of claim 4, further comprising positioning a shield adjacent the neutron source to absorb stray neutrons.

6. The method of claim 5, further comprising positioning a moderator between the neutron source and the material specimen.

7. The method of claim 6, further comprising positioning a reflector adjacent the neutron source to reflect neutrons toward the material specimen.

8. The method of claim 1, wherein mounting a neutron source adjacent the material specimen comprises mounting an isotopic neutron source adjacent the material specimen.

9. The method of claim 8, wherein mounting an isotopic neutron source adjacent the material specimen comprises mounting a neutron source of $^{252}Cf$.

10. The method of claim 1, wherein continuing to collect and process positron annihilation data to measure an accumulation of lattice damage over time is performed while the material specimen is in service.

11. The method of claim 1, wherein continuing to collect and process positron annihilation data to measure an accumulation of lattice damage over time is performed during a production process involving the material specimen.

12. A method for evaluating a material specimen, comprising:

mounting a neutron source adjacent the material specimen;

mounting a detector adjacent the material specimen;

bombarding the material specimen with neutrons from the neutron source to create prompt gamma rays within the material specimen, some of the prompt gamma rays being emitted from the material specimen, some of the prompt gamma rays resulting in the formation of positrons within the material specimen by pair production;

collecting positron annihilation data by detecting with the detector at least one emitted annihilation gamma ray resulting from the annihilation of a positron, the detector producing the positron annihilation data;

storing the positron annihilation data on a data storage system for later retrieval and processing; and

continuing to collect and store positron annihilation data, the continued collected and stored positron annihilation data being indicative of an accumulation of lattice damage over

time.

13. The method of claim 12, further comprising:

collecting prompt gamma ray data by detecting with the detector at least one emitted prompt gamma ray, the detector producing the prompt gamma ray data;

storing prompt gamma ray data on the data storage system for later retrieval and processing; and

continuing to collect and store prompt gamma ray data, the continued collected and stored prompt gamma ray data being indicative of an accumulation of lattice damage over time.

14. The method of claim 12, wherein said mounting a neutron source adjacent the material specimen comprises mounting the neutron source to the material specimen.

15. The method of claim 14, wherein said mounting a detector adjacent the material specimen comprises mounting the detector to the material specimen.

16. The method of claim 15, further comprising positioning a shield adjacent the neutron source to absorb stray neutrons.

17. The method of claim 16, further comprising positioning a moderator between the neutron source and the material specimen.

18. The method of claim 12, wherein mounting a neutron source adjacent the material specimen comprises mounting an isotopic neutron source adjacent the material specimen.

19. The method of claim 12, wherein continuing to collect and store positron annihilation data is performed while the material specimen is in service.

20. The method of claim 12, wherein continuing to collect and store positron annihilation data is performed during a production process involving the material specimen.

21. The method of claim 12, further comprising:

retrieving stored positron annihilation data; and

processing the positron annihilation data in accordance with a Doppler-broadening algorithm to produce output data indicative of an accumulation of lattice damage over time.

22. The method of claim 1, further comprising removing the neutron source before collecting positron annihilation data.

23. The method of claim 12, further comprising removing the neutron source before collecting positron annihilation data.

24. A method for evaluating a material specimen, comprising:

mounting a positron source adjacent the material specimen;

mounting a detector adjacent the material specimen;

bombarding the material specimen with positrons from the positron source to create prompt gamma rays within the material specimen, some of the prompt gamma rays being emitted from the material specimen, some of the prompt gamma rays resulting in the formation of positrons within the material specimen by pair production;

collecting positron annihilation data by detecting with the detector at least one emitted annihilation gamma ray resulting from the annihilation of a positron, the detector producing the positron annihilation data;

processing collected positron annihilation data in accordance with a Doppler-broadening algorithm; and

continuing to collect and process positron annihilation data to measure an accumulation of lattice damage over time.